

(12) **United States Patent**
Suzumura et al.

(10) **Patent No.:** **US 10,882,569 B2**
(45) **Date of Patent:** **Jan. 5, 2021**

(54) **VEHICLE BODY REINFORCING STRUCTURE AND MANUFACTURING METHOD OF VEHICLE BODY REINFORCING STRUCTURE**

(71) Applicant: **Toyota Jidosha Kabushiki Kaisha**,
Toyota (JP)

(72) Inventors: **Haruki Suzumura**, Kariya (JP);
Hiroshi Kuno, Kariya (JP); **Tomoki Kitagawa**, Kariya (JP)

(73) Assignee: **Toyota Jidosha Kabushiki Kaisha**,
Toyota (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 122 days.

(21) Appl. No.: **16/361,942**

(22) Filed: **Mar. 22, 2019**

(65) **Prior Publication Data**
US 2019/0300073 A1 Oct. 3, 2019

(30) **Foreign Application Priority Data**
Mar. 28, 2018 (JP) 2018-062747

(51) **Int. Cl.**
B60J 5/00 (2006.01)
B62D 29/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **B62D 29/005** (2013.01); **B60J 5/101** (2013.01); **B62D 25/025** (2013.01); **B62D 25/04** (2013.01); **B62D 29/002** (2013.01)

(58) **Field of Classification Search**
CPC .. B62D 25/025; B62D 25/2036; B62D 25/04; B62D 25/087; B29K 2105/06;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,130,614 A * 12/1978 Saidla B29C 44/145
264/257
5,395,153 A * 3/1995 De Smet B60J 5/0426
296/146.6

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2005-186751 A 7/2005
JP 2005-319662 A 11/2005

(Continued)

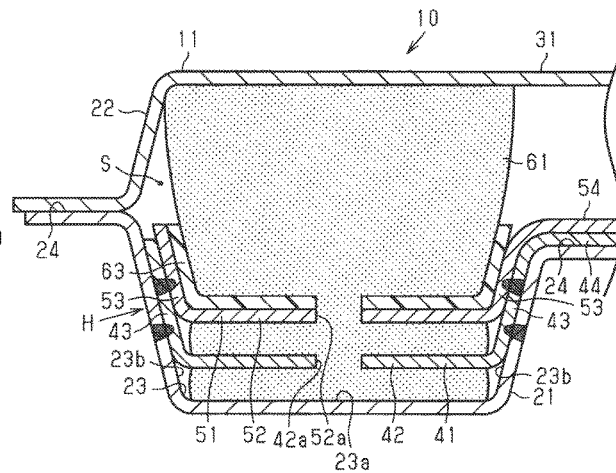
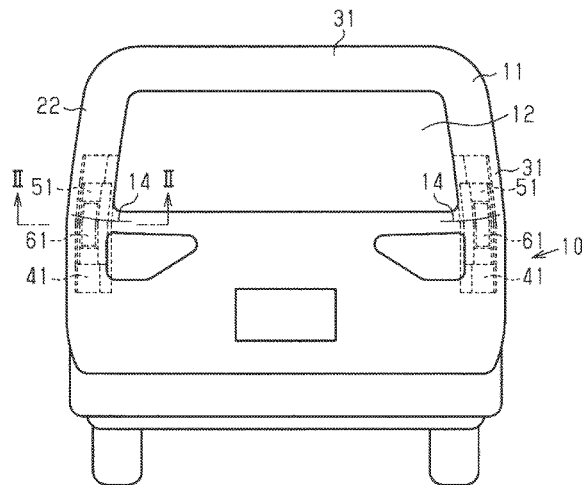
Primary Examiner — Kiran B Patel

(74) *Attorney, Agent, or Firm* — Dinsmore & Shohl LLP

(57) **ABSTRACT**

A vehicle body reinforcing structure includes: a panel-shaped reinforcing member having a through-hole penetrating through the reinforcing member in a plate-thickness direction of the reinforcing member and located inside a closed-section structure of a vehicle body framework portion; a first panel located at a position closer to an outside of the vehicle than the reinforcing member is; a second panel constituting the closed-section structure with the first panel and located at a position closer to an inside of the vehicle than the reinforcing member is; and a foaming adhesive member filled in an internal space of the closed-section structure, wherein the first panel and the second panel are bonded to each other by the foaming adhesive member penetrating through the through-hole of the reinforcing member, and the foaming adhesive member is filled between the first panel and the reinforcing member and between the second panel and the reinforcing member.

5 Claims, 4 Drawing Sheets



- (51) **Int. Cl.**
B60J 5/10 (2006.01)
B62D 25/02 (2006.01)
B62D 25/04 (2006.01)
- (58) **Field of Classification Search**
 CPC B29K 2309/08; Y10T 428/239; Y10T
 428/24149; B29C 66/71; B29C 66/7212
 See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,518,806 A * 5/1996 Eder B29C 44/5636
 181/288
 5,755,486 A * 5/1998 Wycech B29C 70/78
 296/187.02
 5,884,960 A * 3/1999 Wycech B29C 44/1228
 296/146.6
 6,096,403 A * 8/2000 Wycech B29C 44/1228
 428/122
 6,168,226 B1 * 1/2001 Wycech B62D 29/007
 296/146.6
 6,199,940 B1 * 3/2001 Hopton B60J 5/0447
 296/146.6
 6,321,793 B1 * 11/2001 Czaplicki B29C 44/18
 138/172
 6,341,467 B1 * 1/2002 Wycech B29C 44/18
 296/193.06
 6,350,513 B1 * 2/2002 Melquist B32B 5/18
 428/313.3
 6,378,933 B1 * 4/2002 Schoen B62D 29/002
 296/187.02
 6,419,305 B1 * 7/2002 Larsen B62D 25/04
 296/187.02
 6,467,834 B1 * 10/2002 Barz B62D 25/04
 296/187.02
 6,471,285 B1 * 10/2002 Czaplicki B62D 29/002
 296/187.02
 6,519,854 B2 * 2/2003 Blank B62D 21/157
 29/402.09
 6,550,847 B2 * 4/2003 Honda B29C 44/1228
 296/146.6
 6,662,424 B2 * 12/2003 Ehrlich B60P 7/0815
 29/428
 6,866,331 B2 * 3/2005 Kropfeld B62D 29/002
 296/146.6
 6,883,858 B2 * 4/2005 Barz B62D 29/002
 296/187.02
 7,125,461 B2 * 10/2006 Czaplicki B62D 29/002
 156/79
 7,318,873 B2 * 1/2008 Czaplicki B29C 70/70
 156/293

7,497,504 B2 * 3/2009 Peters B60J 5/0444
 296/146.6
 7,513,564 B2 * 4/2009 Yamazaki B62D 29/002
 296/187.02
 7,641,264 B2 * 1/2010 Niezur B62D 25/00
 296/187.02
 7,790,280 B2 * 9/2010 Busseuil B62D 25/00
 296/187.01
 8,042,768 B2 * 10/2011 Liguore B29C 70/088
 244/119
 8,297,675 B2 * 10/2012 Someschan B60R 13/02
 264/46.5
 8,511,743 B2 * 8/2013 Kraushaar B62D 21/15
 296/187.02
 8,608,232 B2 * 12/2013 Engertsberger B62D 25/04
 296/187.12
 8,690,228 B2 * 4/2014 Marchesano F16B 2/22
 296/191
 8,926,005 B2 * 1/2015 Barz B62D 25/04
 296/193.06
 9,120,276 B2 * 9/2015 Wittenberg B29C 70/885
 9,702,391 B2 * 7/2017 Erlacher C09J 5/08
 9,776,666 B2 * 10/2017 Yamada B62D 29/002
 9,925,736 B2 * 3/2018 Cox B21B 1/22
 9,944,325 B2 * 4/2018 Murray B60R 19/42
 10,106,205 B2 * 10/2018 Richardson B29C 69/02
 10,266,098 B1 * 4/2019 Cox B21C 23/00
 10,363,974 B2 * 7/2019 Cox B62D 25/2054
 10,556,413 B2 * 2/2020 Cossins B32B 3/12
 2002/0033618 A1 * 3/2002 Kwon B62D 29/002
 296/203.03
 2003/0090129 A1 * 5/2003 Riley B62D 21/152
 296/203.03
 2004/0191107 A1 * 9/2004 Ishikawa B22F 7/006
 419/2
 2004/0217626 A1 * 11/2004 Barz B62D 25/04
 296/187.02
 2007/0090666 A1 * 4/2007 Brennecke B60J 5/0451
 296/146.6
 2008/0029200 A1 * 2/2008 Sheasley C08L 63/00
 156/79
 2009/0085379 A1 * 4/2009 Takahashi B62D 25/04
 296/193.06
 2013/0064666 A1 * 3/2013 Thomas B64C 27/72
 416/158
 2014/0084633 A1 * 3/2014 Matsuda B62D 25/02
 296/203.01

FOREIGN PATENT DOCUMENTS

JP 2010-111328 A 5/2010
 JP 2011-136606 A 7/2011

* cited by examiner

FIG. 1A

FIG. 1B

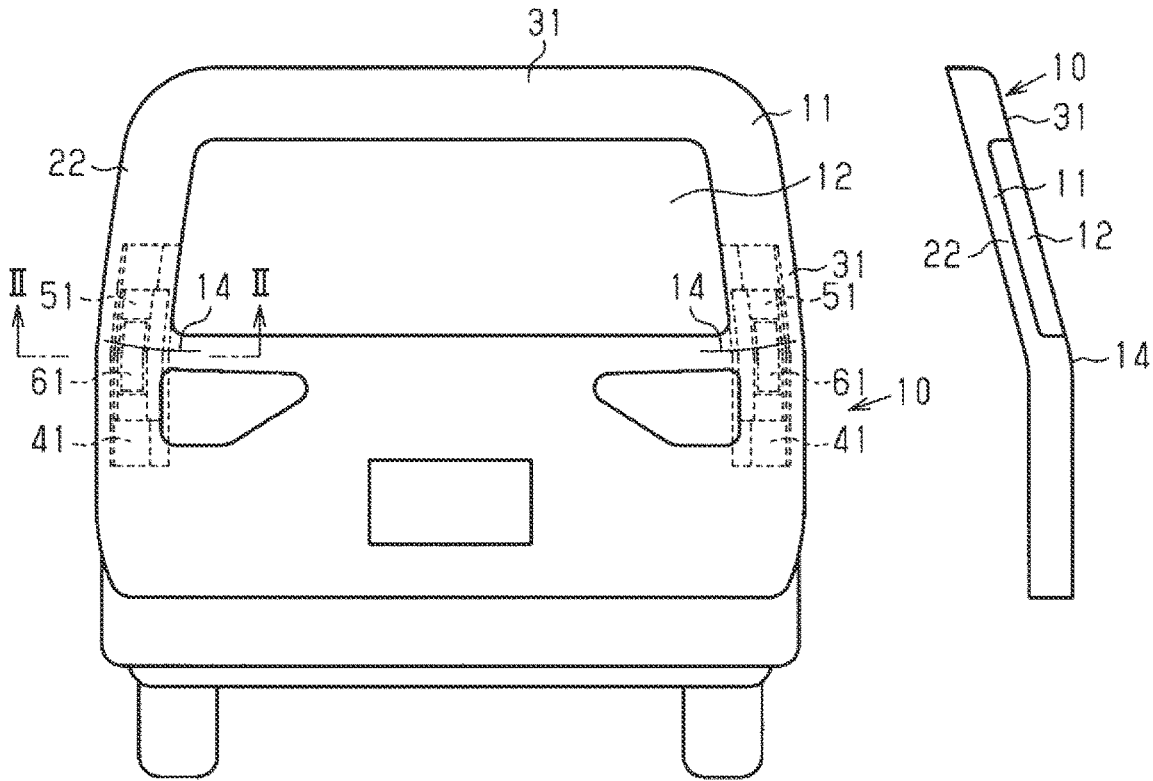


FIG. 2

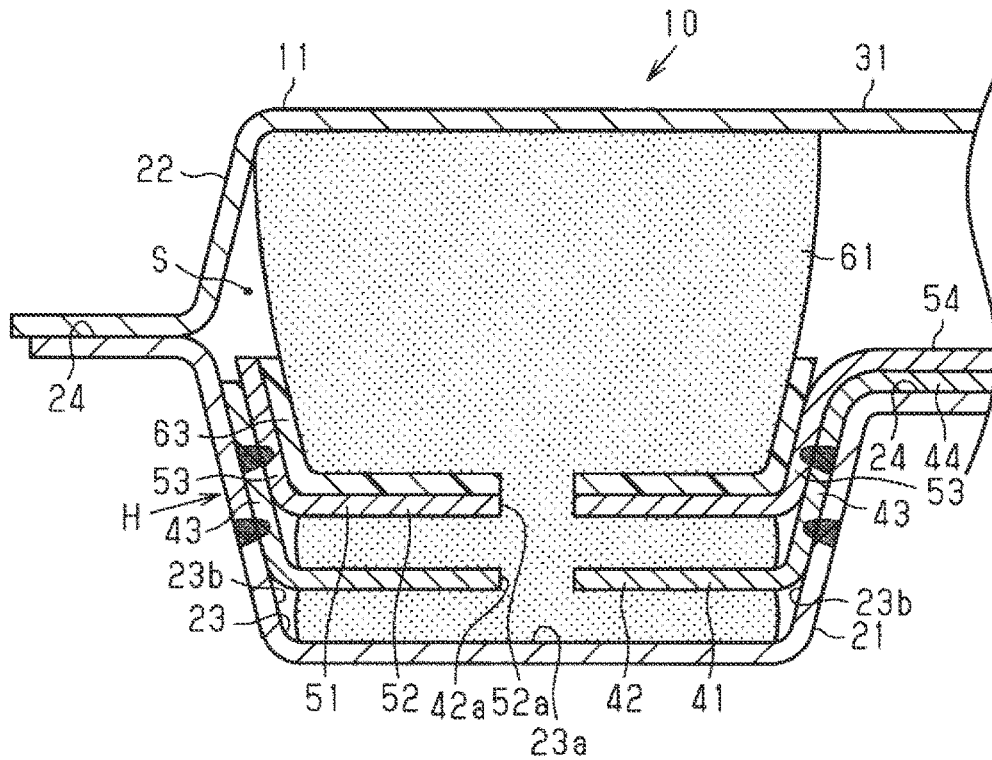


FIG. 3

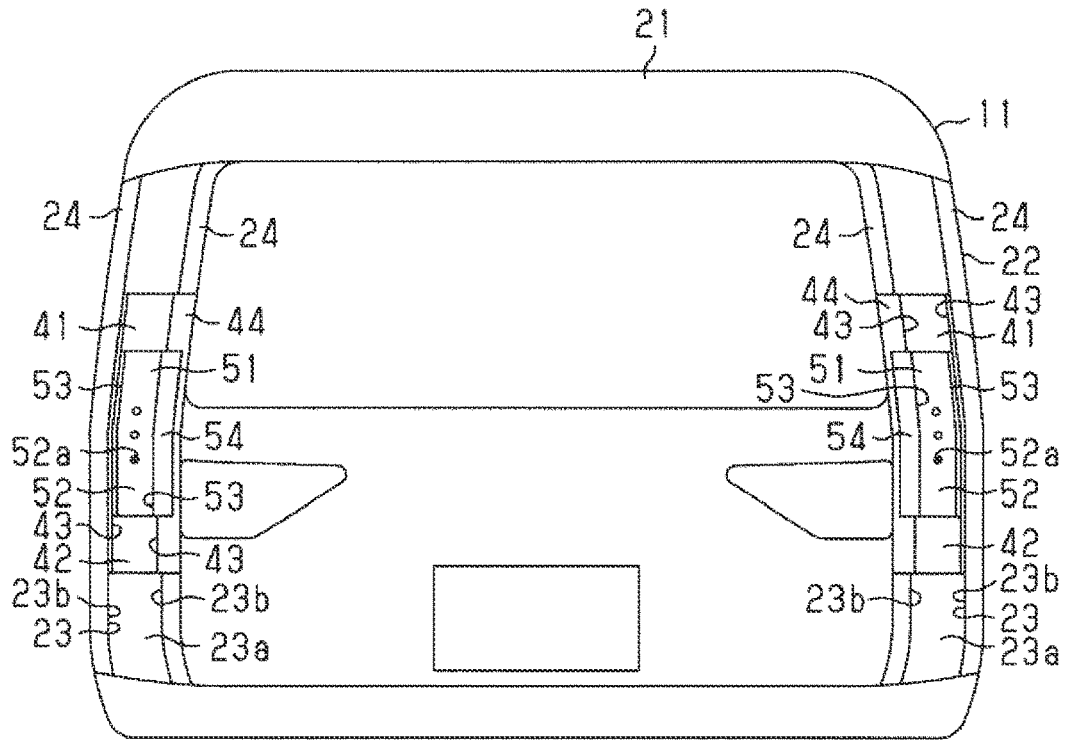


FIG. 4

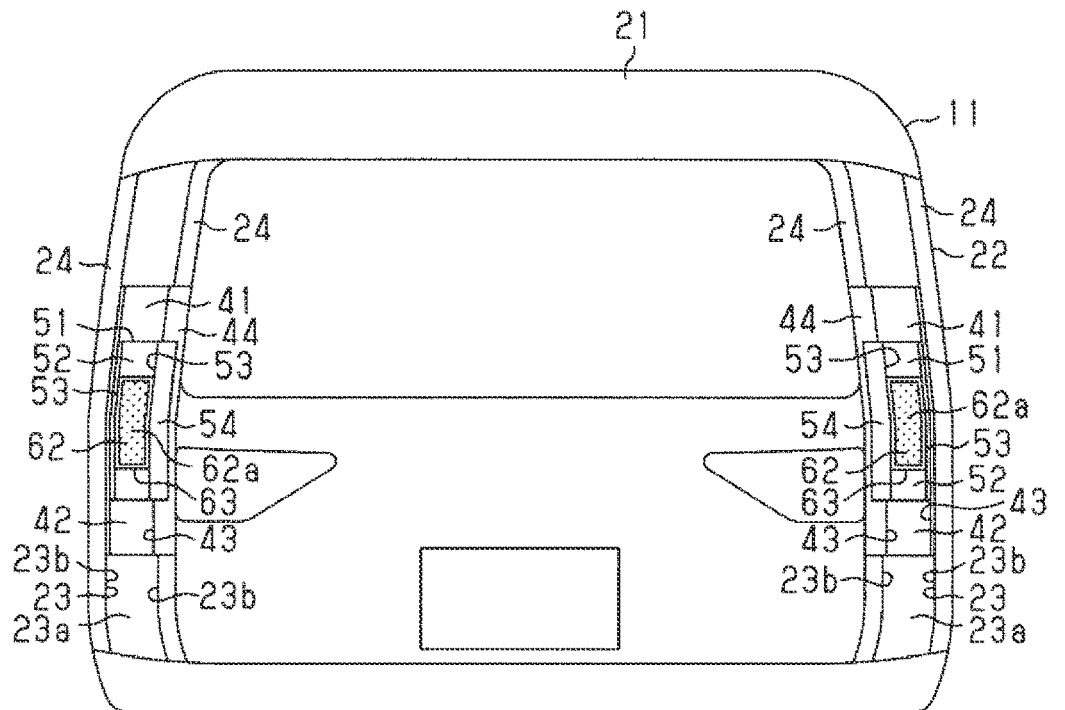


FIG. 5

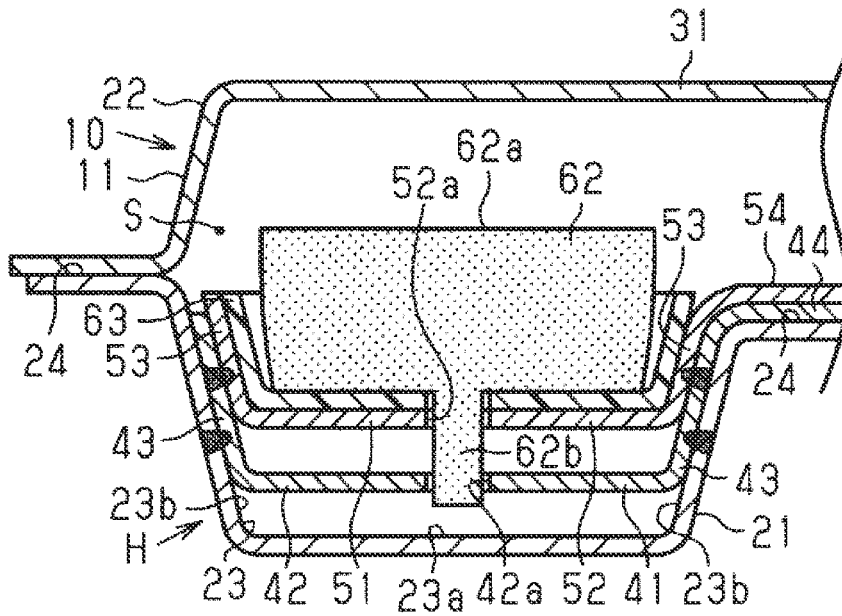
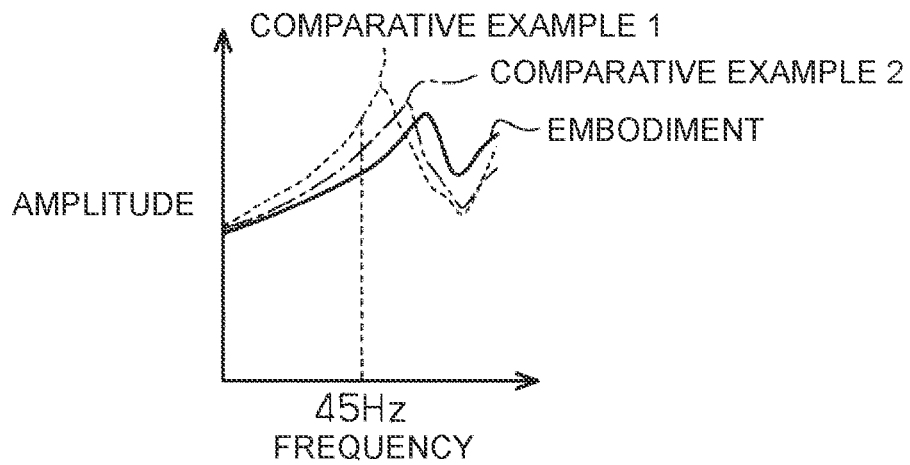


FIG. 6



**VEHICLE BODY REINFORCING
STRUCTURE AND MANUFACTURING
METHOD OF VEHICLE BODY
REINFORCING STRUCTURE**

CROSS-REFERENCE TO RELATED
APPLICATIONS

This application claims priority to Japanese Patent Application No. 2018-062747 filed on Mar. 28, 2018, which is incorporated herein by reference in its entirety including the specification, drawings and abstract.

BACKGROUND

1. Technical Field

The disclosure relates to a vehicle body reinforcing structure and a manufacturing method of the vehicle body reinforcing structure.

2. Description of Related Art

As a vehicle body reinforcing structure for a vehicle such as an automobile, there is a reinforcing structure for a back door as described in Japanese Unexamined Patent Application Publication No. 2011-136606 (JP 2011-136606 A), for example. The reinforcing structure for the back door as described in JP 2011-136606 A includes an inner panel having a window frame portion (a vehicle body framework portion) for a back window glass, and metal hinge reinforcements disposed on the opposite side faces of the window frame portion so as to cover the window frame portion from its upper part to its lower part. Further, the reinforcing structure for the back door includes an upper outer panel and a lower outer panel placed on the inner panel via the hinge reinforcements so as to face each other at an interval in the height direction. The hinge reinforcements are placed inside an internal space of a closed-section structure constituted by the inner panel and the outer panels, so that the rigidity of the back door is increased by the hinge reinforcements.

SUMMARY

Some back doors have a structure bending near a border between the upper outer panel and the lower outer panel, that is, near the lower part of the window frame portion like JP 2011-136606 A. In a bending portion of the structure, sectional areas of the panels constituting the closed-section structure are small, so that it is requested to increase the rigidity of the bending portion. Further, as well as the back door, it is requested to increase the rigidity in a vehicle body framework portion such as a front pillar or a center pillar of a vehicle. As a method for increasing the rigidity, it is conceivable that the thicknesses of the inner panel, the outer panel, and the reinforcement are increased or more reinforcements are added. However, in this case, the weight of the reinforcing structure increases and the weight of a vehicle body increases, so this is unfavorable.

The disclosure provides a vehicle body reinforcing structure that can restrain an increase in weight and increase rigidity, and a manufacturing method of the vehicle body reinforcing structure.

A first aspect of the disclosure provides a vehicle body reinforcing structure. The vehicle body reinforcing structure includes: a reinforcing member having a through-hole penetrating through the reinforcing member in a plate-thickness

direction of the reinforcing member, the reinforcing member being located inside a closed-section structure of a vehicle body framework portion of a vehicle, the reinforcing member being panel-shaped; a first panel located at a position closer to an outside of the vehicle than the reinforcing member is; a second panel constituting the closed-section structure together with the first panel, the second panel being located at a position closer to an inside of the vehicle than the reinforcing member is; and a foaming adhesive member filled in an internal space of the closed-section structure, wherein the first panel and the second panel are bonded to each other by the foaming adhesive member penetrating through the through-hole of the reinforcing member, and the foaming adhesive member is filled, in the internal space, between the first panel and the reinforcing member and between the second panel and the reinforcing member.

According to the above configuration, the foaming adhesive member penetrates through the through-holes of the reinforcing member. Accordingly, even in a structure in which the reinforcing member is placed between the first panel and the second panel, the first panel and the second panel can be bonded to each other with the foaming adhesive member. Since the reinforcing member is placed between the first panel and the second panel, a part between the first panel and the second panel can be reinforced by the foaming adhesive member, so that the rigidity of the vehicle body framework portion can be increased. Accordingly, in the vehicle body framework portion including the first panel, the second panel, the reinforcing member, and the foaming adhesive member, the rigidity of the vehicle body framework portion can be increased without adding reinforcing members or without increasing the plate thicknesses of the reinforcing member and the panels.

In the first aspect of the disclosure, the reinforcing member, the first panel, and the second panel may be arranged along a joining direction in which the first panel and the second panel are joined to each other, and the foaming adhesive member may extend along the joining direction between the first panel and the second panel.

According to the above configuration, the closed-section structure is easily crushed in the joining direction where the first panel and the second panel are joined to each other, but since the foaming adhesive member is provided to extend in the joining direction, the rigidity in the joining direction can be increased.

In the first aspect of the disclosure, the first panel may be an outer panel, the second panel may be an inner panel, and the reinforcing member may be a reinforcement. According to the above configuration, since the through-holes are provided in the reinforcement placed in the closed-section structure constituted by the inner panel and the outer panel and the foaming adhesive member is provided to penetrate through the through-holes, it is possible to increase the rigidity of the vehicle body framework portion using the reinforcement.

In the first aspect of the disclosure, the vehicle body reinforcing structure may include a plurality of the reinforcements. According to the above configuration, since the through-holes are provided in the reinforcements and the foaming adhesive member is provided to penetrate through the through-holes, it is possible to increase the rigidity of the vehicle body framework portion using the reinforcements.

A second aspect of the disclosure provides a manufacturing method of a vehicle body reinforcing structure. The manufacturing method of a vehicle body reinforcing structure includes: (a) placing a first panel, with a predetermined space between the first panel and a reinforcing member, at

a position closer to an outside of a vehicle than the reinforcing member is, the reinforcing member being panel-shaped, the reinforcing member having a through-hole penetrating through the reinforcing member in a plate-thickness direction of the reinforcing member, and the reinforcing member being placed inside a closed-section structure of a vehicle body framework portion of the vehicle; (b) placing a second panel, with a predetermined space between the second panel and the reinforcing member, at a position closer to an inside of the vehicle than the reinforcing member is; (c) forming the closed-section structure, by step (a) and step (b), the second panel constituting the closed-section structure together with the first panel; (d) placing a precursor of a foaming adhesive member in an internal space of the closed-section structure; (e) after step (d), heating the precursor to foam; and (f) after step (e), causing the precursor to penetrate through the through-hole such that the foaming adhesive member is filled between the reinforcing member and the first panel and between the reinforcing member and the second panel.

According to the configuration, it is possible to cause the foaming precursor to penetrate through the through-holes by providing the through-holes in the reinforcing member. As a result, the foaming precursor reaches the first panel and the second panel between which the reinforcing member is sandwiched. Accordingly, the first panel and the second panel can be bonded to each other with the foaming adhesive member, when the precursor hardens to become the foaming adhesive member. Further, the foaming adhesive member can be filled between the reinforcing member and the first panel and between the reinforcing member and the second panel, by causing the foaming precursor to penetrate through the through-holes.

BRIEF DESCRIPTION OF THE DRAWINGS

Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1A is a front view illustrating a back door;

FIG. 1B is a side view illustrating the back door;

FIG. 2 is a sectional view taken along a line II-II in FIG. 1A and illustrating a reinforcing structure of the back door;

FIG. 3 is a front view illustrating a first reinforcement and a second reinforcement;

FIG. 4 is a front view illustrating a state where a precursor of a high-rigidity foaming adhesive member is placed;

FIG. 5 is a sectional view illustrating a state where the precursor of the high rigidity foaming adhesive member is placed;

FIG. 6 is a graph illustrating a relationship between frequency and sound pressure; and

FIG. 7 is a sectional view illustrating a reinforcing structure of another example.

DETAILED DESCRIPTION OF EMBODIMENTS

The following describes one embodiment in which a vehicle body reinforcing structure and a manufacturing method of the vehicle body reinforcing structure are embodied as a reinforcing structure for a back door and its manufacturing method, with reference to FIGS. 1A to 6. As illustrated in FIG. 1A, a back door 10 includes a back door frame 11 as a vehicle body framework portion, and a vehicle window panel 12. The back door frame 11 is made of

aluminum. As illustrated in FIG. 1B, the back door 10 includes bending portions 14 at positions sandwiching the vehicle window panel 12 in the vehicle width direction. The back door 10 has a shape bending in the front-rear direction due to the bending portions 14.

As illustrated in FIG. 2, the back door frame 11 includes an inner panel 21 placed on a side closer to the inside of a vehicle, and an outer panel 31 placed on a side closer to the outside of the vehicle. Further, the back door frame 11 includes a first reinforcement 41 and a second reinforcement 51 placed inside an internal space S of a closed-section structure H constituted by the inner panel 21 and the outer panel 31, and a high-rigidity foaming adhesive member 61. The high-rigidity foaming adhesive member 61 is placed to step over the bending portion 14. The outer panel 31 constitutes a first panel placed on the side closer to the outside of the vehicle than the first reinforcement 41 and the second reinforcement 51, and the inner panel 21 constitutes a second panel placed on the side closer to the inside of the vehicle than the first reinforcement 41 and the second reinforcement 51.

As illustrated in FIG. 2 or FIG. 3, the inner panel 21 is made of aluminum and includes a window frame portion 22. The inner panel 21 includes recessed portions 23 provided on the opposite sides of the inner panel 21 in the vehicle width direction and recessed toward the inside of the vehicle. Each of the recessed portions 23 extends in the vehicle up-down direction and is provided to step over its corresponding bending portion 14. The recessed portion 23 is defined by a bottom face 23a and side faces 23b extending toward the outside of the vehicle from edge portions, of the bottom face 23a, that extend in the up-down direction. Further, the inner panel 21 includes joining surfaces 24 extending in the vehicle width direction from the side faces 23b of the recessed portions 23.

The first reinforcement 41 and the second reinforcement 51 are partially placed in the recessed portion 23 of the inner panel 21. The first reinforcement 41 and the second reinforcement 51 are made of aluminum in a panel shape.

The first reinforcement 41 has a shape in which long sides extend in the vehicle up-down direction and has a generally hat-shaped section perpendicular to the longitudinal direction. The first reinforcement 41 includes a first bottom wall 42 in which long sides extend in the vehicle up-down direction, first side walls 43 projecting from long edges provided in a pair in the first bottom wall 42, and a first flange 44 extending from the first side wall 43 on the inner side in the vehicle width direction, out of the first side walls 43 thus provided in a pair.

The first reinforcement 41 includes a plurality of first through-holes 42a penetrating through the first bottom wall 42 in its plate-thickness direction. The first through-holes 42a are adjacently provided in the vehicle up-down direction. The first reinforcement 41 is placed in the inner panel 21 in a state where the first bottom wall 42 and the first side walls 43 are accommodated in the recessed portion 23. The first bottom wall 42 is distanced from the bottom face 23a of the recessed portion 23. The first side walls 43 are placed along the side faces 23b of the recessed portion 23. The first reinforcement 41 is joined to the inner panel 21 by welding the first side walls 43 thereto. Further, the first flange 44 of the first reinforcement 41 is joined by welding to the joining surface 24 of the inner panel 21 in a state where the first flange 44 is put thereon.

The second reinforcement 51 has a shape in which long sides extend in the vehicle up-down direction and has a generally hat-shaped section perpendicular to the longitudi-

nal direction. The second reinforcement **51** includes a second bottom wall **52** in which long sides extend in the vehicle up-down direction, second side walls **53** projecting from long edges provided in a pair in the second bottom wall **52**, and a second flange **54** extending from the second side wall **53** on the inner side in the vehicle width direction, out of the second side walls **53** thus provided in a pair. The second reinforcement **51** includes a plurality of second through-holes **52a** penetrating through the second bottom wall **52** in its plate-thickness direction. The second through-holes **52a** are adjacently provided in the vehicle up-down direction.

The second reinforcement **51** is placed in the inner panel **21** in a state where the second bottom wall **52** and the second side walls **53** are accommodated inside the first side walls **43** of the first reinforcement **41**. Accordingly, the second reinforcement **51** is placed inside the first reinforcement **41** accommodated in the recessed portion **23**. The second bottom wall **52** is distanced from the first bottom wall **42** of the first reinforcement **41**. Further, the second through-holes **52a** of the second bottom wall **52** face the first through-holes **42a** of the first reinforcement **41**.

The second side walls **53** are placed along the first side walls **43** of the first reinforcement **41**. The second reinforcement **51** is joined such that the second side walls **53** are welded to the first side walls **43** of the first reinforcement **41**. Further, the second flange **54** of the second reinforcement **51** is joined to the joining surface **24** of the inner panel **21** by welding at a position that does not overlap with the first flange **44**.

The outer panel **31** is joined to the joining surface **24** of the inner panel **21**, and a closed-section structure H formed by the outer panel **31** and the inner panel **21** is formed on each side of the window frame portion **22** along the vehicle width direction. In the closed-section structure H of the present embodiment, the first reinforcement **41** and the second reinforcement **51** serve as reinforcing members having through-holes. The outer panel **31** placed on the side closer to the outside of the vehicle than the second reinforcement **51** that is one of the reinforcing members constitutes a first panel, and the inner panel **21** placed on the side closer to the inside of the vehicle than the first reinforcement **41** that is the other one of the reinforcing members constitutes a second panel.

The internal space S is sectioned in the closed-section structure H, and the internal space S is filled with the high-rigidity foaming adhesive member **61**. The high-rigidity foaming adhesive member **61** is made of an epoxy-based foam material and constitutes a foam layer to have necessary rigidity and adhesiveness.

The high-rigidity foaming adhesive member **61** is formed such that its precursor **62** is heated to foam. As illustrated in FIG. 4 or FIG. 5, the precursor **62** includes an elongated block-shaped body portion **62a** extending in the vehicle up-down direction, and bar-shaped leg portions **62b** provided to extend from the body portion **62a**. The body portion **62a** is placed inside the second reinforcement **51**, and the leg portions **62b** are inserted into the second through-holes **52a** and the first through-holes **42a**. The precursor **62** of the high-rigidity foaming adhesive member **61** is held by a generally plate-shaped resin holding member **63** in an integrated manner. The precursor **62** is attached to the second reinforcement **51** with locking portions (not shown) such as clips formed in the holding member **63**. Note that the number of locking portions and positions where the locking portions are provided are determined in accordance with the shape of the second reinforcement **51**. In a state where the precursor **62** is placed inside the second reinforcement **51**,

the precursor **62** is attached to the second reinforcement **51** with the locking portions. The precursor **62** is placed in a state where the holding member **63** is provided between the body portion **62a** and the second bottom wall **52** of the second reinforcement **51**.

Here, a manufacturing method of the reinforcing structure for the back door **10** will be described. First, the first reinforcement **41** is joined to the inner panel **21**, and the second reinforcement **51** is joined to the first reinforcement **41**. Then, the precursor **62** is placed in the second reinforcement **51**, and the precursor **62** is attached to the second reinforcement **51** with the locking portions of the holding member **63**. At this time, the leg portions **62b** of the precursor **62** are inserted into the second through-holes **52a** of the second reinforcement **51** and the first through-holes **42a** of the first reinforcement **41**. After that, the outer panel **31** is joined to the inner panel **21**. As a result, the closed-section structure H is formed by the inner panel **21** and the outer panel **31**, and the precursor **62** is placed in the internal space S of the closed-section structure H.

As illustrated in FIG. 5, in a state where the precursor **62** is placed in the internal space S, there is a space between the precursor **62** and the outer panel **31**. Further, the second bottom wall **52** of the second reinforcement **51** and the first bottom wall **42** of the first reinforcement **41** are placed with a space, except parts where the leg portions **62b** are provided. Also, the first bottom wall **42** and the inner panel **21** are placed with a space.

Subsequently, a coating step is performed on the back door **10**, and a drying step is performed after that. In the drying step, when the back door **10** is heated to 150° C. to 200° C., the precursor **62** is heated by heat at the time of drying. As a result, the precursor **62** foams.

The body portion **62a** of the precursor **62** thus foaming buries a part between the second bottom wall **52** and the outer panel **31** in the internal space S. Further, the leg portions **62b** of the precursor **62** thus foaming enter a part between the second bottom wall **52** and the first bottom wall **42** and also enter a part between the first bottom wall **42** and the bottom face **23a** of the inner panel **21**, so that the internal space S of the closed-section structure H is filled with the foamed precursor **62**. The precursor **62** hardens in that state to become the high-rigidity foaming adhesive member **61**, so that the reinforcing structure for the back door **10** is completed.

As illustrated in FIG. 2, in the reinforcing structure for the back door **10**, a part of the high-rigidity foaming adhesive member **61** is filled between the outer panel **31** and the second reinforcement **51** so as to bond the outer panel **31** to the second reinforcement **51**. Further, a part of the high-rigidity foaming adhesive member **61** penetrates through the second through-holes **52a** of the second reinforcement **51** and is filled between the second bottom wall **52** of the second reinforcement **51** and the first bottom wall **42** of the first reinforcement **41**, so as to bond the second bottom wall **52** to the first bottom wall **42**. Further, the high-rigidity foaming adhesive member **61** penetrates through the first through-holes **42a** of the first reinforcement **41**, so as to bond the first bottom wall **42** of the first reinforcement **41** to the bottom face **23a** of the inner panel **21**.

The high-rigidity foaming adhesive member **61** bonds the outer panel **31** to the inner panel **21** and is provided in a column shape between the outer panel **31** and the inner panel **21** so as to reinforce the vicinity of the bending portion **14** of the back door **10**. That is, the high-rigidity foaming adhesive member **61** is provided in a column shape along a joining direction where the inner panel **21** and the outer

panel 31 are joined to each other, so that the high-rigidity foaming adhesive member 61 reinforces the vicinity of the bending portion 14 of the window frame portion 22. Further, in the closed-section structure H, the first bottom wall 42 of the first reinforcement 41 and the second bottom wall 52 of the second reinforcement 51 are adjacently provided in the joining direction where the outer panel 31 and the inner panel 21 are joined to each other. Accordingly, in the closed-section structure H, the first bottom wall 42, the second bottom wall 52, and a part of the high-rigidity foaming adhesive member 61 are laminated along the joining direction.

Next will be described the action of the reinforcing structure for the back door 10. In the back door 10, the vicinity of the bending portion 14 of the window frame portion 22 is reinforced by the first reinforcement 41 and the second reinforcement 51 and is also reinforced by the high-rigidity foaming adhesive member 61, so that the rigidity is increased.

Further, the back door 10 has a shape in which a part below the bending portion 14 easily slightly vibrates in the vehicle front-rear direction around the bending portion 14 as a pivoting origin, and besides, the back door 10 is made of a material such as aluminum that has a Young's modulus smaller than that of an iron-based material. However, the high-rigidity foaming adhesive member 61 is bonded to the inner panel 21 and the outer panel 31 so that the panels 21, 31 are connected to each other with the high-rigidity foaming adhesive member 61, thereby restraining slight vibrations of the inner panel 21 and the outer panel 31.

When an external force is applied to a vehicle body of the vehicle or the back door 10 at the time when the vehicle runs or the back door 10 is opened and closed, natural vibrations in which vibrations continue due to an internal force occur. In the graph in FIG. 6, the vibration characteristic of the back door 10 in the embodiment is indicated by a continuous line, and the vibration characteristic of a back door in Comparative Example 1 in which the closed-section structure H is not filled with the high-rigidity foaming adhesive member 61 is indicated by a broken line. Further, in the graph in FIG. 6, an alternate long and short dash line indicates the vibration characteristic of a back door in Comparative Example 2 in which the closed-section structure H is filled with the high-rigidity foaming adhesive member 61 and only the second reinforcement 51 and the outer panel 31 are bonded to each other with the high-rigidity foaming adhesive member 61. In Comparative Example 2, the high-rigidity foaming adhesive member 61 does not penetrate through the first reinforcement 41 and the second reinforcement 51. In the graph of FIG. 6, the lateral axis indicates frequency, and the vertical axis indicates magnitude of a sound pressure.

As illustrated by the continuous line in FIG. 6, in the present embodiment, the reinforcing structure is provided, so that the natural frequency of the back door 10 is higher than those in Comparative Example 1 and Comparative Example 2. The natural frequency of the vehicle body is around 45 Hz, and thus, the natural frequency of the back door 10 in the embodiment is greatly separated from the natural frequency of the vehicle body in comparison with Comparative Example 1 and Comparative Example 2, so that resonance between the vehicle body and the back door 10 is avoided more.

With the embodiment, it is possible to yield the following effects.

(1) The high-rigidity foaming adhesive member 61 penetrates through the first through-holes 42a and the second

through-holes 52a, so that the inner panel 21 and the outer panel 31 are bonded to each other with the high-rigidity foaming adhesive member 61. Accordingly, even in the reinforcing structure in which the first and second reinforcements 41, 51 are placed between the inner panel 21 and the outer panel 31, the inner panel 21 and the outer panel 31 can be bonded to each other via the high-rigidity foaming adhesive member 61. In addition, the high-rigidity foaming adhesive member 61 can be filled between the second reinforcement 51 and the first reinforcement 41 and between the first reinforcement 41 and the inner panel 21. As a result, even in the vicinity of the bending portion 14 in which the closed-section structure H has a small sectional area, it is possible to increase the rigidity without adding reinforcements or without increasing the plate thicknesses of the panels 21, 31 and the reinforcements 41, 51.

(2) The back door 10 is configured such that the vicinity of the bending portion 14 of the window frame portion 22 is filled with the high-rigidity foaming adhesive member 61 to increase the rigidity, thereby restraining slight vibrations of the back door 10. On this account, the natural frequency of the back door 10 can be greatly separated from the natural frequency of the vehicle body, thereby making it possible to avoid resonance between the vehicle body and the back door 10.

(3) With the first through-holes 42a and the second through-holes 52a, the first reinforcement 41 can be bonded to the second reinforcement 51 and the first reinforcement 41 can be bonded to the inner panel 21 both with the high-rigidity foaming adhesive member 61. On this account, even if the inner panel 21 cannot be welded to the first bottom wall 42 of the first reinforcement 41, the inner panel 21 can be joined to the first reinforcement 41 with the high-rigidity foaming adhesive member 61, thereby making it possible to increase the rigidity.

(4) Since the high-rigidity foaming adhesive member 61 is provided between the inner panel 21 and the outer panel 31, the high-rigidity foaming adhesive member 61 increases the rigidity in the joining direction where the inner panel 21 and the outer panel 31 are joined to each other. On this account, it is possible to increase the rigidity of the closed-section structure H in a direction where the closed-section structure H is easily crushed.

(5) In the drying step after the coating step, the precursor 62 of the high-rigidity foaming adhesive member 61 is heated to foam, so that the precursor 62 expanding in volume is filled into the internal space S of the closed-section structure H. On this account, the high-rigidity foaming adhesive member 61 can be filled into a narrow space such as a space between the second reinforcement 51 and the first reinforcement 41 or a space between the first reinforcement 41 and the inner panel 21. Further, in consideration of the sealing characteristic of the back door 10, even the bottom face 23a of the inner panel 21 and the first bottom wall 42 of the first reinforcement 41 that cannot be welded can be bonded to each other with the high-rigidity foaming adhesive member 61.

(6) The inner panel 21, the first reinforcement 41, and the second reinforcement 51 are made of aluminum, and therefore, these three members cannot be welded collectively, so that it is difficult to increase the rigidity by increasing the number of welding parts. However, by filling the high-rigidity foaming adhesive member 61, the inner panel 21, the first reinforcement 41, and the second reinforcement 51 can be integrated by bonding, so that the rigidity of the back door 10 can be increased.

(7) In order to reduce the weight of the back door **10**, the inner panel **21**, the outer panel **31**, the first reinforcement **41**, and the second reinforcement **51** are made of aluminum. Aluminum has a Young's modulus smaller than that of an iron-based material. The high-rigidity foaming adhesive member **61** is filled into the internal space S, so that the inner panel **21**, the first reinforcement **41**, the second reinforcement **51**, and the outer panel **31** are bonded to each other. Hereby, slight vibrations can be restrained. As a result, it is possible to greatly separate the natural frequency of the back door **10** from the natural frequency of the vehicle body, thereby making it possible to avoid resonance between the vehicle body and the back door **10** and to reduce noise and vibration that an occupant feels inside a vehicle cabin.

Note that the above embodiment can be modified as follows.

As illustrated in FIG. 7, the second through-holes **52a** are formed only in the second bottom wall **52** of the second reinforcement **51**, and the first through-holes **42a** are not formed in the first reinforcement **41**. Then, the second reinforcement **51** having the second through-holes **52a** is provided as a reinforcing member, the outer panel **31** placed on the side closer to the outside of the vehicle than the second reinforcement **51** is provided as a first panel, and the first reinforcement **41** placed on the side closer to the inside of the vehicle than the second reinforcement **51** is provided as a second panel. Then, the high-rigidity foaming adhesive member **61** is provided to penetrate through the second through-holes **52a** of the second reinforcement **51**, and hereby, a structure in which the outer panel **31** is bonded to the first reinforcement **41** with the high-rigidity foaming adhesive member **61** may be formed. Even in such a configuration, the high-rigidity foaming adhesive member **61** is provided between the outer panel **31** and the first reinforcement **41**, so that the rigidity of the closed-section structure H can be increased.

Although not illustrated herein, the first through-holes **42a** are formed only in the first bottom wall **42** of the first reinforcement **41**, and the second through-holes **52a** are not formed in the second reinforcement **51**. Then, the first reinforcement **41** having the first through-holes **42a** is provided as a reinforcing member, the second reinforcement **51** provided on the side closer to the outside of the vehicle than the first reinforcement **41** is provided as a first panel, and the inner panel **21** provided on the side closer to the inside of the vehicle than the first reinforcement **41** is provided as a second panel. Then, the high-rigidity foaming adhesive member **61** is provided to penetrate through the first through-holes **42a** of the first reinforcement **41**, so that a structure in which the inner panel **21** is bonded to the second reinforcement **51** with the high-rigidity foaming adhesive member **61** may be formed. Even in such a configuration, the high-rigidity foaming adhesive member **61** is provided between the inner panel **21** and the second reinforcement **51**, so that the rigidity of the closed-section structure H can be increased.

In a case where a side panel having a design surface is placed on the side closer to the inside of the vehicle than the inner panel **21**, for example, in the embodiment, a through-hole may be provided in the inner panel **21**, and the high-rigidity foaming adhesive member **61** may be provided to penetrate through the second through-holes **52a**, the first through-holes **42a**, and the through-hole provided in the inner panel **21**, so that the side panel is bonded to the outer panel **31** with the high-rigidity foaming adhesive member **61**. In this case, the inner panel **21**, the first reinforcement **41**, and the second reinforcement **51** serve as reinforcing

members, the outer panel **31** placed on the side closer to the outside of the vehicle than the second reinforcement **51** serves as a first panel, and the side panel placed on the side closer to the inside of the vehicle than the inner panel **21** serves as a second panel.

In the embodiment, the first through-holes **42a** are provided in the first bottom wall **42** of the first reinforcement **41**, and the second through-holes **52a** are provided in the second bottom wall **52** of the second reinforcement **51**, but the places where the through-holes are provided may be changed. For example, through-holes may be provided in the first side wall **43** of the first reinforcement **41**, and the high-rigidity foaming adhesive member **61** penetrating through the first side wall **43** may be bonded to the side face **23b** of the inner panel **21**. Alternatively, through-holes may be provided in the second side wall **53** of the second reinforcement **51**, and the high-rigidity foaming adhesive member **61** penetrating through the second side wall **53** may be bonded to the first side wall **43** of the first reinforcement **41**.

Even in this case, the rigidity of the closed-section structure H can be increased by the high-rigidity foaming adhesive member **61**.

The reinforcing structure may be applied to members other than the back door **10**. For example, the reinforcing structure may be applied to a vehicle body framework portion having a closed-section structure formed by joining an outer panel and an inner panel, e.g., a front pillar, a center pillar, a rear pillar, a roof side rail, or the like.

Only one reinforcement may be placed in the internal space S of the closed-section structure H. In this case, the one reinforcement serves as a reinforcing member, the outer panel **31** serves as a first panel, and the inner panel **21** serves as a second panel.

In the embodiment, the heating of the precursor **62** is performed in the heating step after the coating step in the manufacturing process of the back door **10**, but the disclosure is not limited to this. For example, the heating may be performed after the inner panel **21**, the first reinforcement **41**, the second reinforcement **51**, the precursor **62**, and the outer panel **31** are assembled, but before the coating step is performed.

The material for the inner panel **21**, the first reinforcement **41**, and the second reinforcement **51** may be a metal other than aluminum.

What is claimed is:

1. A vehicle body reinforcing structure comprising:
 - a reinforcing member having a through-hole penetrating through the reinforcing member in a plate-thickness direction of the reinforcing member, the reinforcing member being located inside a closed-section structure of a vehicle body framework portion of a vehicle, the reinforcing member being panel-shaped;
 - a first panel located at a position closer to an outside of the vehicle than the reinforcing member is;
 - a second panel constituting the closed-section structure together with the first panel, the second panel being located at a position closer to an inside of the vehicle than the reinforcing member is; and
 - a foaming adhesive member filled in an internal space of the closed-section structure, wherein the first panel and the second panel are bonded to each other by the foaming adhesive member penetrating through the through-hole of the reinforcing member, and

11

the foaming adhesive member is filled, in the internal space, between the first panel and the reinforcing member and between the second panel and the reinforcing member.

2. The vehicle body reinforcing structure according to claim 1, wherein:

the reinforcing member, the first panel, and the second panel are arranged along a joining direction in which the first panel and the second panel are joined to each other; and

the foaming adhesive member extends along the joining direction between the first panel and the second panel.

3. The vehicle body reinforcing structure according to claim 1, wherein the first panel is an outer panel, the second panel is an inner panel, and the reinforcing member is a reinforcement.

4. The vehicle body reinforcing structure according to claim 3, wherein the vehicle body reinforcing structure includes a plurality of the reinforcements.

5. A manufacturing method of a vehicle body reinforcing structure comprising:

(a) placing a first panel, with a predetermined space between the first panel and a reinforcing member, at a position closer to an outside of a vehicle than the

12

reinforcing member is, the reinforcing member being panel-shaped, the reinforcing member having a through-hole penetrating through the reinforcing member in a plate-thickness direction of the reinforcing member, and the reinforcing member being placed inside a closed-section structure of a vehicle body framework portion of the vehicle;

(b) placing a second panel, with a predetermined space between the second panel and the reinforcing member, at a position closer to an inside of the vehicle than the reinforcing member is;

(c) forming the closed-section structure, by step (a) and step (b), the second panel constituting the closed-section structure together with the first panel;

(d) placing a precursor of a foaming adhesive member in an internal space of the closed-section structure;

(e) after step (d), heating the precursor to foam; and

(f) after step (e), causing the precursor to penetrate through the through-hole such that the foaming adhesive member is filled between the reinforcing member and the first panel and between the reinforcing member and the second panel.

* * * * *